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Original research

Techniques and outcomes of combined inferior vena cava and visceral resection for benign and malignant disease

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HIGHLIGHTS

- Long-term follow-up of a radical surgical approach to heretofore unresectable tumours.
- Excellent quality intra-operative pictures.
- Limited published literature available on this topic.

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ABSTRACT

Background: Involvement of the inferior vena cava (IVC) by neoplasm has traditionally been considered a contra-indication to curative surgery because of high surgical risks and poor long-term prognosis. Advances in surgical and anaesthetic techniques however have made this feasible. The aim of this study is to evaluate the outcome of combined IVC and visceral resection in a single institution.

Methods: A retrospective review of a prospectively maintained database was performed. Pre-operative clinicopathological data, operative details and post-operative outcomes including overall and disease-free survival were analysed. Clinicopathological data of patients over a seven-year period undergoing combined IVC and visceral resection was reviewed, including overall and disease-free survival.

Results: Between 2006 and 2012, 14 patients underwent IVC resection was accompanied by major hepatectomy (8), nephrectomy (6) and multivisceral resection (3). Post resection, the IVC was reconstructed primarily (3); with PTFE tube graft (9) or using a Gore-tex patch graft (2). All patients underwent a R0 resection. There were two postoperative deaths within 30 days. 6 patients had postoperative complications. There was 1 early and one late (after 6 months) IVC thrombosis. With a median follow up of 20 months (range 5–84 months), two patients died of tumour recurrence and ten are alive with ($n = 5$) or without ($n = 5$) disease.

Conclusion: Combined IVC and visceral resection can be safely performed in selected patients. Surgery provides the possibility of negative margins, acceptable perioperative morbidity/mortality and prolonged survival. These factors combined with lack of alternative treatments justify this approach. However, specialist teams should perform the surgery preferably in centres with expertise in liver transplantation.

1. Introduction

Resection of the inferior vena cava (IVC) with or without associated visceral resection poses a significant technical challenge. With refined surgical techniques and improved peri-operative management however, a number of groups have reported their results demonstrating that this is now a feasible management option [1–4]. In patients with no viable oncological alternative, possible benefits of resection include R0 resection, acceptable operative morbidity and prolonged survival. However, there is a scarcity of data addressing the technical nuances, post-operative and oncological outcome from these resections. The aim of this study is to review the role and benefit of combined multivisceral and IVC resection in the setting of a variety of indications and to review the pre- and intra-operative factors determining outcome.

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2. Methods

Data was interrogated for all patients undergoing ICV resection along with other organ(s) from January 2006 to November 2012, at the Department of Surgery, St. Vincent's University Hospital, Dublin. Their clinicopathological and peri-operative details were reviewed from a prospectively maintained database. The selection criteria employed for IVC resection with or without associated visceral resection included the exclusion of metastatic disease, evaluation of the anatomical relationship of the lesion in relation to hepatic veins and other organs with high-resolution computed tomography (CT), pre-operative anaesthetic assessment including echocardiogram and pulmonary function tests; and in the case of a proposed combined liver resection, the absence of cirrhosis or ascites, platelet count $\geq 100 \times 10^9$/L, and a functional liver reserve volume of greater than 25%. All potential cases were reviewed at a multi-disciplinary team conference.

2.1. Statistical analysis

Disease-free and overall survivals were assessed by Kaplan–Meier methods. Continuous variables were expressed in median (range) and compared between subgroups when appropriate using the Mann–Whitney *U*-test. Categorical variables were compared between subgroups using the chi-squared test. A *P*-value ≤ 0.05 was considered to be significant. Statistical analysis was performed using computer software GraphPad Prism version 6.0 for Mac, GraphPad Software, La Jolla California USA (www.graphpad.com).

2.2. Operative technique

On induction, all patients were prepared for the possible use of veno-venous bypass and also so as to avoid hypothermia. Surgical exposure was obtained via a right subcostal incision with midline sternal extension. An intra-operative ultrasonography was performed routinely to detect any tumour invasion into the hepatic and/or renal veins, or any additional metastatic disease not appreciated on pre-operative imaging. The falciform ligament was then divided and the suprahepatic inferior vena cava and hepatic veins exposed (Fig. 1).

The surgical oncological principle of a no-touch technique was employed where possible and all specimens were removed en bloc. For example, in the case of an IVC leiomyosarcoma with extension into the right hepatic vine, an anterior approach to the right hepatectomy was performed as described elsewhere [5] (Fig. 2).

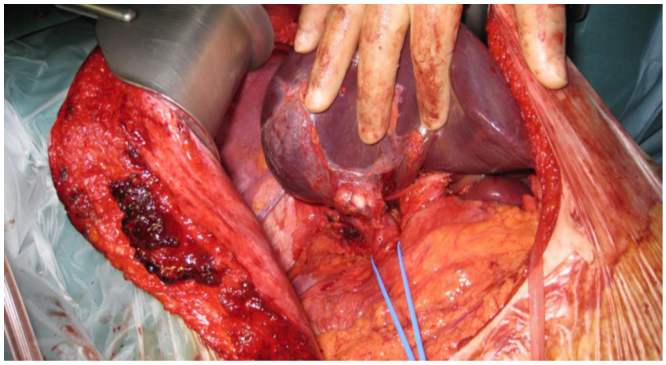

Fig. 1. Intra-operative photo representing adequate mobilisation of the retro-hepatic and supra-hepatic IVC in the case of a leiomyosarcoma of the IVC.

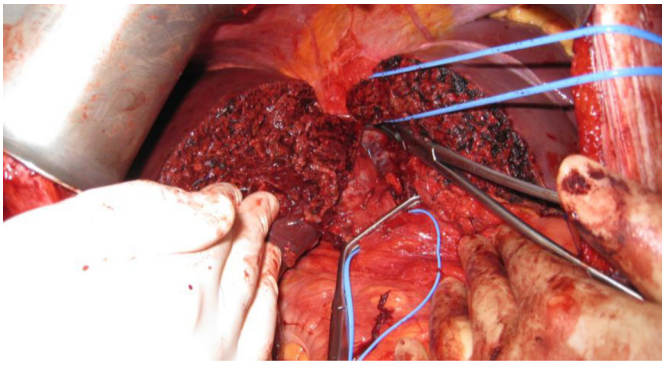

Fig. 2. Anterior approach to the IVC in the case of a sarcoma involving the cava and right hepatic vein.

When employed, parenchymal transection was performed with an ultrasonic dissector under a low central venous pressure (<5 mmHg) achieved by intravenous fluid restriction with or without a low dose of intravenous frusemide (5–10 mg). An intermittent Pringle manoeuver was applied when excessive bleeding was encountered during parenchymal transection. If clamps had to be placed above the hepatic veins on the IVC, then complete hepatic vascular exclusion was used. Veno-venous bypass was indicated whenever there was a risk of tearing a major intrahepatic vessel, especially hepatic veins in the proximity of the IVC or the IVC itself. Whenever possible though, hepatic vascular exclusion with preservation of caval flow was employed in order to improve haemodynamic tolerance.

Reconstruction of the IVC depended on the extent of IVC resection, the tumour location and extent of IVC infiltration. When the IVC wall involvement was longitudinal and less than 25% of its circumference, a tangential resection was performed and closed with a 3/0-running prolene suture. When involvement of the IVC wall compression was greater than 50% of its circumference with or without lumen occlusion, a caval segment was resected and replaced with a 20 mm ringed polytetrafluoroethylene (PTFE) graft (Fig. 3) or a goretex patch (Fig. 4).

3. Results

Fourteen patients were identified, the mean age of which was 55.3 years (35–71) with nine females. Surgical indications included

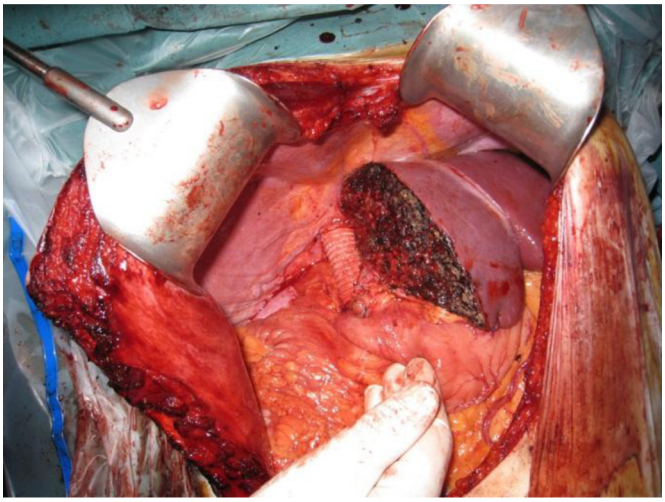

Fig. 3. PTFE tube graft placement as caval replacement following extensive resection.

Fig. 4. Post-operative CT illustrating a Dacron patch in situ following cavotomy and resection.

hepatocellular carcinoma, cholangiocarcinoma, recurrent non-seminomatous germ cell tumour, colorectal liver metastases, adrenocortical carcinoma, Castleman's disease, recurrent phaeochromocytoma, paraganglioma, renal cell carcinoma (3) and IVC leiomyosarcoma (3). Table 1 summarises the intra-operative and immediate post-operative data.

Veno-venous bypass was used in 7 patients (femoral only in 5, portal only in 1 and portal-femoral with in situ hypothermic perfusion in 1). Peri-operative blood transfusion was required in 13 patients. In 3 cases, the IVC was amenable to primary closure as described. 2 cases required a goretex patch and the remaining 9 required a caval segmental resection with PTFE graft replacement. The majority of cases involving concomitant liver resection involved a right (6) or extended right hepatectomy (3). 1 case involved and extended left hepatectomy, and 4 cases did not require any associated liver resection at the time of surgery. No case required re-implantation of a remaining hepatic vein.

There were 2 in-hospital mortalities; the first on day 17 from multi-organ failure which manifested within 24 h of an extensive resection including pancreaticoduodenectomy, right hemi-colectomy, right nephrectomy and IVC resection for a recurrent phaeochromocytoma. The second, from multi-organ failure and sepsis following a right hepatectomy and IVC resection for hepatocellular carcinoma arising in a non-cirrhotic liver. There were 6 post-operative morbidities in 4 patients, all of which resolved before discharge. No cases post-operatively satisfied the ISGLS criteria for post-resection liver failure [6]. All resections were R0 on histological examination with the IVC pathologically involved in 10 of 14.

Table 1
Intra-operative and immediate post-operative data.

Length of procedure (mins)	347 (250–510)
Blood loss (mls)	2690 (800–22,000)
Complications	
Myocardial infarction	1
Wound infection	1
Renal failure (requiring dialysis)	1
Chylous ascites	1
Intra-abdominal collection	2
Graft thrombosis	1
Bile leak	0
30-day mortality	2

As there is no level 1 evidence for the use of anti-coagulation after IVC resection and/or reconstruction, this decision was left to individual surgeon preference. Of those placed on aspirin, one developed symptoms suggesting IVC obstruction within one month post-operatively (bilateral lower limb oedema) and imaging revealed a thrombosed PTFE graft. This was thrombolysed and the patient subsequently placed on warfarin. Of those who were not commenced on aspirin (4), one had evidence of PTFE graft partial thrombosis at routine 6-monthly imaging, but had developed multiple collaterals and was asymptomatic. This patient was subsequently placed on aspirin only.

The median follow-up was 20 months (5–84). The 1-, 3- and 5-year disease-free survivals in patients who survived beyond 30 days were 75%, 33% and 33% respectively (Fig 5) and the corresponding overall survival rates in all 14 patients were 57%, 43% and 29% respectively. Disease recurrences (5 patients) were all extra-hepatic and all included lung metastases. Table 2 categorises which disease types recurred.

4. Discussion

Resection of the IVC was described as far back as 1976 [7] for isolated leiomyosarcoma, with the first IVC resection en bloc with liver tumour being described in 1980, in a patient with HCC, replacing the resected IVC with a cadaveric vein [8]. However if the literature demonstrates anything it is that this type of aggressive surgical management is only indicated in highly selected patients, and this in turn reflects the nature of the surgery and of the disease processes that lead to possible indications for such radical surgery. All patients in this cohort went through a multi-disciplinary team discussion forum following full work-up and it was only when all other treatment options were exhausted that resection of this magnitude was considered. For example, in the case of the

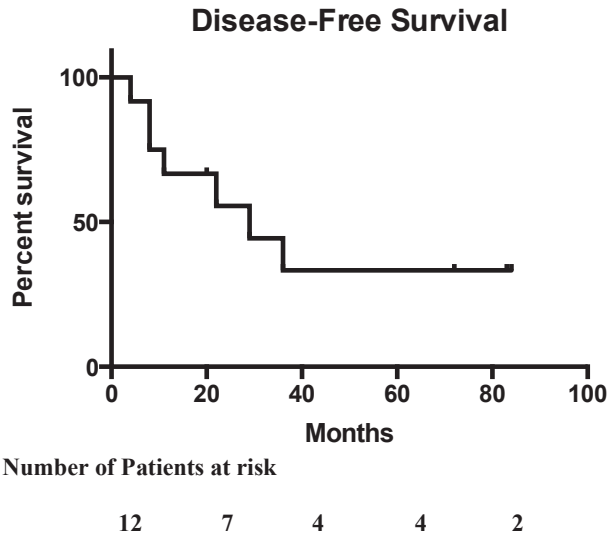

Fig. 5. Disease-free survival of the cohort of patients undergoing IVC and visceral resection (excluding those not surviving the first 30 days).

Table 2
Follow-up as per disease type.

Alive with no evidence of disease recurrence
Paraganglioma
Cholangiocarcinoma
Renal cell carcinoma
Castleman's disease
Non-seminomatous germ cell tumour
Alive with evidence of disease recurrence
Colorectal liver metastases
IVC Leiomyosarcoma (3)
Renal cell carcinoma
Dead with tumour recurrence
Renal cell carcinoma
Adrenocortical carcinoma

hepatocellular carcinoma arising in the non-cirrhotic liver, this lesion underwent two sessions of trans-arterial chemo-embolisation (TACE) before being considered for surgery, but did not respond radiologically in a meaningful way, and so the decision was taken to resect.

The indications for veno-venous bypass have been well-established and most authorities would say that it be used on a selective basis only [9]. For this particular cohort of patients the authors see no reason that resection of the cava itself should mandate routine use of bypass.

Histologically, despite 14 R0 resections, 4 of the 14 resections (29%) had no histological evidence of caval involvement. This raises questions about the optimal pre-operative assessment of the caval involvement in these patients, as alluded to by Nuzzo et al. [10]. The ideal method remains undefined, however it is clear that if it is technically feasible and safe to resect cava in the interests of achieving a complete oncological clearance, then this is preferred to leaving and R1 or even R2 clearance.

The procedure of caval and visceral resection is a formidable challenge and should only be undertaken following a meticulous pre-operative workup and by surgery and anaesthetic teams experienced in liver transplant. The morbidity and mortality reported in this series is not insignificant and remains a major consideration when planning such resections, however the achievement of a 5 year overall and disease-free survival in 33% and 29% respectively is encouraging in patients who would otherwise have a dismal prognosis.

5. Conclusion

This study demonstrates that combined IVC and visceral resection is a safe and oncologically appropriate operation for a variety of disease processes that heretofore had few alternative approaches and a guarded prognosis. Resectability on pre-operative imaging is a good predictor of an R0 resection in this series. And it seems that the major determinant of overall and disease-free survival in those who survive the initial insult is tumour biology.

Ethical approval

Data was investigated from a prospectively maintained database and so ethical approval was not required by the St. Vincent's University Hospital Ethics Committee.

Sources of funding

None to declare.

Author contribution

Tom Gallagher – Study design, wrote the manuscript.
KV Udupa – Data Collection.
JG Geoghegan – Study design, critical review of the manuscript.
Donal Maguire – critical review of the manuscript.
Oscar Traynor – critical review of the manuscript.
Emir Hoti – Senior Author, critical review of data, analysis and manuscript.

Conflicts of interest

None to declare – for all authors.

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